

**SEMATECH 1987 -- 1997**

**A Final Report to the Department of Defense**

**February 21, 1997**

9.7.97

## **Executive Summary**

In 1987 the Defense Science Board Task Force on Semiconductor Dependency stated in its report that, "U.S. leadership in semiconductor manufacturing is rapidly eroding." The Board recognized that U.S. military forces depend heavily on technological superiority to win and that loss of technological leadership and consequent dependence on foreign sources of supply for state-of-the-art semiconductor devices was an "unacceptable situation." The "principal and most crucial recommendation of the Task Force" was the creation of an industry-government consortium to "develop, demonstrate and advance the technology base for efficient, high yield manufacture of advanced semiconductor devices."

Congress voted to match industry contributions to conduct precompetitive research in a non-profit consortium and SEMATECH was born. Following the direction of the Defense Science Board and its Board of Directors, SEMATECH focused on the infrastructure of the integrated circuit manufacturers -- the capital equipment, methods and processes used to fabricate semiconductor devices. SEMATECH's Board believed that focusing on precompetitive challenges such as manufacturing capability and productivity improvement would free resources which SEMATECH member companies could then direct toward product design, quality and innovation. This strategy was intended to facilitate SEMATECH members in regaining a position of world leadership in semiconductor manufacturing by leveraging the historical strength of the U.S. industry -- innovative product development.

By 1992 the U.S. industry had indeed regained worldwide leadership in semiconductor manufacturing. In July of 1994, with the U.S. industry in full rebound, the SEMATECH Board voted to proceed in a new direction without federal funding for the consortium. The \$50 million included in a supplemental Department of Defense spending bill late in fiscal year 1996 marked the final appropriation for SEMATECH. Beginning as a bold experiment in industry-government cooperation, SEMATECH is moving toward a business model that will rely entirely on private funding -- the partnership has come full circle.

Without the foresight and commitment of three Presidential Administrations and four Congresses, SEMATECH could never have achieved a degree of success which has been called dramatic and unprecedented. The willingness of the U.S. government to eschew partisanship and undertake a bold experiment -- an experiment based on cooperation as opposed to traditional procurement, and with accountability standards rooted in trust instead of elaborate regulations -- has led the U.S. to a position of preeminence in an industry which is vital to our nation's security and economic well-being.

This transition report will provide a systematic review of SEMATECH's operations from 1988 -- 1996 and detail the consortium's compliance with statutory requirements. The future relationship between SEMATECH and the United States government will be discussed as well.

## **Operational Overview**

### Mission

SEMATECH was incorporated in 1987 as a Delaware not-for-profit membership corporation. It is exempt from federal income taxes under § 501(c)(6) of the Internal Revenue Code. While the overarching objective of SEMATECH has been to facilitate its members in regaining a position of global manufacturing leadership, the firm's mission statement has evolved over time. The evolution of SEMATECH's mission statements can be considered a barometer of response to the dynamism of the semiconductor industry. Two such statements from early in SEMATECH's history are:

*To provide the U.S. semiconductor industry the domestic capability for world leadership in manufacturing*

*SEMATECH Board of Directors, August 1987*

*Create fundamental change in manufacturing technology and the domestic infrastructure to provide U.S. semiconductor companies the continuing capability to be world-class suppliers.*

*SEMATECH Board of Directors, August 1991*

These early statements reflect the severe challenge which the U.S. semiconductor industry faced in the late 1980's and early 1990's. SEMATECH responded with a broad, multifaceted program aimed at shoring up the domestic infrastructure of the semiconductor industry. Major initiatives in critical processing technologies such as lithography, furnace and implant, and plasma etch and deposition equipment were launched. SEMATECH members believed that access to world-class manufacturing equipment and methods was the key to recovering a position of leadership in the global market. The strategy was a resounding success. In 1992 the U.S. chip manufacturers, of which the SEMATECH members represented about 75% (on a revenue basis), overtook the Japanese manufacturers in terms of worldwide market share. In a period of

less than five years, SEMATECH, working with its members and the U.S. government, had achieved a comeback that many said would never happen.

With the U.S. industry back in a leadership position SEMATECH might have declared victory and ceased operations; however, the SEMATECH members and government participants firmly believed that in order to sustain and secure the U.S. position, SEMATECH should continue operations so long as it continued to provide value to its members. The Board of Directors asserted their continued support for the consortium and asked SEMATECH to take on a broader set of technical challenges, including the areas of design, test, materials, and assembly and packaging technologies. The emphasis was turning from recovery to one of maintaining the leadership position which had been attained. The broadening of SEMATECH's charter is reflected in the evolution of the mission statement:

*Solve the technical challenges required to keep the U.S. number one in the global semiconductor industry.*

*SEMATECH Board of Directors, February 1993*

By 1996 the U.S. leadership position seemed secure; however, it was becoming apparent that the challenges the industry would face in the future would be increasingly complex and unremitting. With the threat of industry demise behind them, the Board would expect SEMATECH to offer increased competitive advantage and tangible return to its membership.

Without question, many of the developments SEMATECH has delivered have resulted in coincidental and significant benefits to non-SEMATECH member companies. Because SEMATECH has historically emphasized the development and improvement of process equipment and methodologies, much of the fruit of the consortium's labor was contained in the actual hardware or software being offered for sale by U.S. equipment suppliers. Inasmuch as this equipment was available to non-members on an equal basis with SEMATECH members, non-members have received considerable benefits from the program. SEMATECH has always been committed to contributing to the advancement of the U.S. industry and never objected to this peripheral effect. However, as SEMATECH completes its transition to a wholly private enterprise, emphasis must be placed on providing competitive advantage to the consortium membership. This reasoning underlies the current mission statement:

*SEMATECH members will create shared competitive advantage by working together to achieve and strengthen manufacturing technology leadership.*

*SEMATECH Board of Directors, February 1996*

Few industries compare to that of semiconductors with respect to the magnitude and pace with which change occurs. Over time, SEMATECH's mission statement has evolved in response to the changing business environment and the needs of its members. The consortium, however, has remained focused on its objective of establishing a leadership position for U.S. manufacturers.

### Corporate Strategic Objectives

A core set of overarching, strategic objectives have guided the consortium from its very early period through the present day. These objectives were developed in cooperation with SEMATECH member companies and the U.S. Department of Defense. A complete list of the Corporate Strategic Objectives follows.

- Provide member companies with the lowest cost production capability for leading semiconductor devices. Reduce the rate of increase of capital costs per unit output with increasing device complexity.
- Ensure access to a competitive supplier infrastructure capable of meeting the members' requirements for selected key equipment, materials, models, simulation tools and manufacturing systems.
- Provide cost-effective, flexible factory capabilities that can respond to process and product changes with first pass success.
- Provide solutions to the semiconductor industry for environment, safety and health conscious manufacturing.
- Meet each member company's target for return on investment.
- Champion the National Technology Roadmap for Semiconductors and work closely with government and universities to implement timely improvements in semiconductor technology.
- Cooperate with all organizations involved in semiconductor R&D to develop a research and education infrastructure necessary to sustain U.S. leadership in semiconductor technology.

- Maintain open forums for effective communication, collaboration and consensus building within the SEMATECH community.

## Select Accomplishments

By nearly any measure, SEMATECH has been a resounding success. The most obvious and frequently cited supporting evidence has been the dramatic comeback of U.S. semiconductor and equipment manufacturers in the worldwide market place (see Figures 1 and 2). SEMATECH believes that the lion's share of credit for the recovery in the semiconductor market goes to the employees of its member companies. They have demonstrated an unwavering commitment to innovation, aggressive product development and total quality business practices.

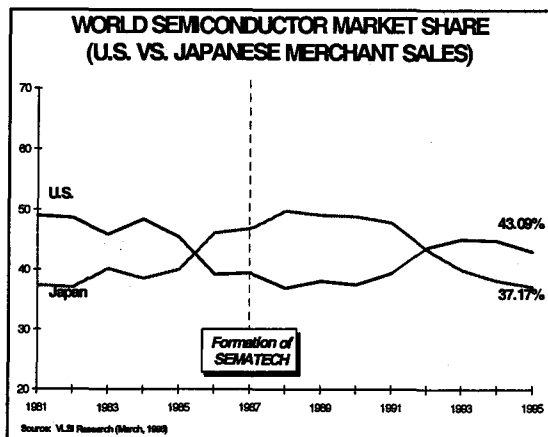


Figure 1

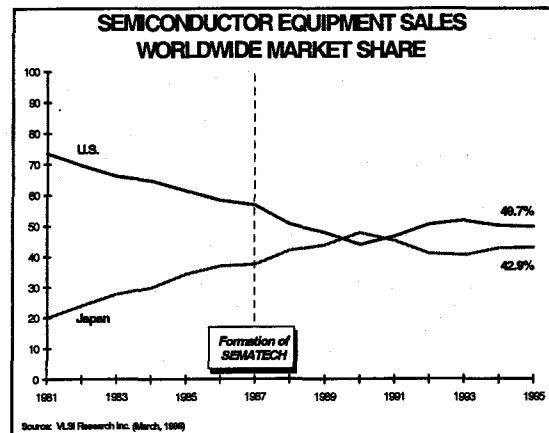


Figure 2

In the case of the semiconductor infrastructure, SEMATECH's work with the equipment suppliers has had a profound impact. Since its inception, the consortium has directed approximately 60% of its resources to technology programs in the infrastructure and can be credited justly with the turnaround in this sector. The General Accounting Office, in a 1992 report, stated:

*"SEMATECH has demonstrated that a government-industry R&D consortium on manufacturing technology can help improve a U.S. industry's technological position while protecting the government's interest that the consortium be managed well and public funds spent appropriately."*

In the same year, Jerry Hutcheson, CEO of VLSI Research, Inc., an independent market research firm, offered the following:

*“Every way I look at the data, I come back to the belief that this has got to be a SEMATECH-driven increase [in world market share for semiconductor equipment made in America.]”*

#### Deliverables to the Department of Defense

- Restoration of an infrastructure of manufacturing equipment and materials suppliers in most key areas of semiconductor technology
- A dramatic improvement in the performance-to-cost ratio for microelectronics in defense systems
- A capacity to exploit through manufacturing the investments DoD has made in system research and development
- A pathway to expanded use of commercial, off-the-shelf (COTS) microelectronic devices for defense systems

#### National Return on Investment

Since SEMATECH was formed, the U.S. government has invested \$848 million, compared to \$863 million by member companies. In return, the government has realized more than \$34.7 billion in tax revenue from SEMATECH's member companies (see Figure 3).

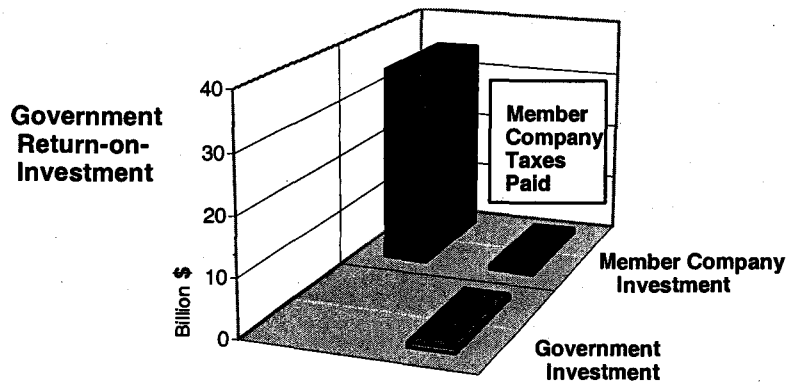


Figure 3

Semiconductor Factory Costs

Ten years ago, the cost of a new fabrication facility was doubling every 29 months. That rate of escalation has slowed to a 15% compound annual growth rate in the nineties (see Figure 4). Minimizing the escalating cost of building and equipping new manufacturing facilities is critical to keeping the industry on its historical productivity curve.

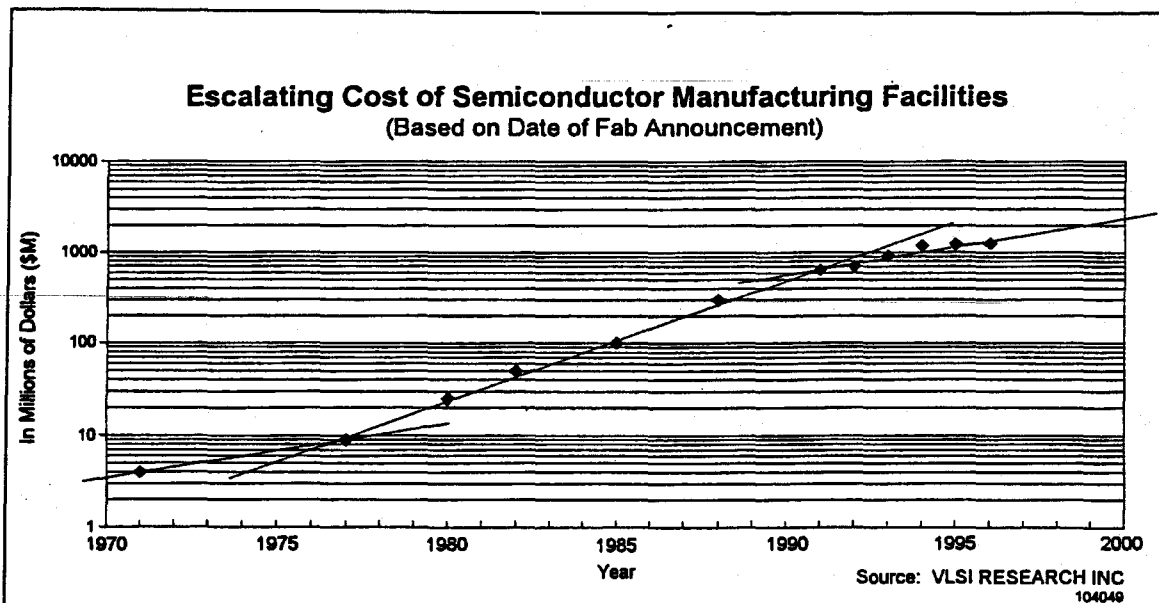


Figure 4



One of the most significant achievements SEMATECH can count among its successes is its role as architect of the National Technology Roadmap for Semiconductors. SEMATECH and the Semiconductor Industry Association (SIA) coordinated with all sectors of the U.S. semiconductor technology base, including government, industry and academia, to produce a document that enables a common vision among all stakeholders. The Roadmap provides a framework for guiding research and development; all relevant segments of the national R&D base can be efficiently enlisted to meet the increasingly complex technology needs of the industry.

The implementation of the research identified in the Roadmap is the responsibility of the SIA, its member companies, their suppliers and the R&D infrastructure of government-supported organizations, universities and other independent research groups. In particular, SEMATECH and the Semiconductor Research Corporation (SRC) support the implementation of critical research identified in the Roadmap.

### ESH

An emphasis on Environment, Safety and Health (ESH) has been a hallmark of the SEMATECH program. Working closely with the Semiconductor Industry Association, SEMATECH took the lead in developing a 15-year, national strategic road map to address ESH issues in the semiconductor industry. The benefits of the road map include aligning industry needs and trends, benchmarking best practices, guiding suppliers in product development, and enabling mapping of research and development plans. While under development, the road map was reviewed by computer chip manufacturers, suppliers, environmental and labor organizations, and members of Congress and their staff.

The ESH road map focuses on five areas: worker protection and ergonomics; tool design; chemical use reduction; emission reduction, and energy and water reduction.

A few examples of SEMATECH's environmental accomplishments follow.

- SEMATECH has co-hosted international symposia which brought together teams of leading experts to exchange information and develop next steps on water conservation, global warming and ergonomics.
- SEMATECH has made significant progress in waste reduction with its reprocessing and recycling techniques. These systems reduce raw material requirements and the transportation of sulfuric acid, and also reduce the use

of chemicals required for waste neutralization and disposal. SEMATECH reuses more than 90% of these acids.

- SEMATECH helped draft and then worked with the industry to adopt uniform ESH guidelines for semiconductor equipment suppliers for the production of equipment and parts.

## **Statutory Compliance**

### Grants to SEMATECH

In accordance with the enabling legislation for SEMATECH (15 U.S.C. §§ 4601-4606), the consortium entered into a memorandum of understanding with the Secretary of Defense and has, throughout its existence, maintained a charter that was agreed to by all representatives of the semiconductor industry that are participating members of the consortium. Additionally, SEMATECH has developed an annual operating plan in consultation with representatives of the Department of Defense and, since its creation, the Semiconductor Technology Council.

SEMATECH has, since its inception, received approximately one-half of its funding from dues paid by its member companies and one-half from a federal grant which has been administered by the Defense Advanced Research Projects Agency of the U.S. Department of Defense. Federal statute mandated that funding from federal, state and local governments could not account for more than 50 percent of the total cost of SEMATECH's research and development activities for a given fiscal year. GAO audits and reviews have shown that SEMATECH has, without exception, met the letter and spirit of this law.

SEMATECH retained an independent, commercial auditor to verify that funds made available to SEMATECH by the United States government were expended in a manner that was consistent with the purposes outlined in the enabling legislation, the firm's charter and the annual operating plans. Without exception, the auditor submitted to the Secretary of Defense, the Comptroller General and SEMATECH management, annual reports certifying SEMATECH's compliance.

From SEMATECH's inception, the Secretary of Defense has been afforded the opportunity to use all intellectual property, trade secrets and technical data developed by SEMATECH in the same manner as a participant of SEMATECH. SEMATECH has taken all steps necessary to maximize the timely and expeditious transfer of technology developed and owned by SEMATECH to the participants in SEMATECH, including the Department of Defense, in accordance with the agreement between SEMATECH and its participants. Early in the consortium's history, SEMATECH established a liaison officer to the Department

of Defense whose primary responsibility was to study and understand the technical needs of the Department and proactively manage the transfer and insertion of technology to DoD.

#### Environment, Safety and Health Program

In the years 1993, 1994, and 1995, the House Armed Services Committee, in its conference committee reports, recommended that SEMATECH spend specified levels of funding for the development of environmentally conscious semiconductor manufacturing methods and processes. Although the committee report language did not rise to the level of federal statute, SEMATECH did provide an annual accounting of its spending on ESH programs to DARPA. In each of the three years, SEMATECH's ESH program expenditures exceeded the congressional guidelines, at times by more than twice the federal recommendation.

#### Semiconductor Technology Council

Following the establishment of the Semiconductor Technology Council in 1994, the consortium has worked closely with the Council and has developed its annual operating plans in cooperation with the STC. SEMATECH has provided status reports to the STC at each of its meetings and has provided administrative support to the Council.

#### **SEMATECH's Future Relationship with DoD**

The partnership between the U.S. semiconductor industry and the Department of Defense, through SEMATECH, has proven to be invaluable. Industry and government will continue to make considerable R&D investments in semiconductor technology far into the future. While industry objectives are primarily aimed at ensuring continued productivity growth and product innovation, DoD's principal objective is to ensure national security. With no reversal of recent troop reductions in the offing, DoD recognizes that technology is a "force multiplier," offsetting the numerical advantage of potential adversaries. As the first annual report of the Semiconductor Technology Council stated, "The need for DoD to take the lead in information technology is manifest. Studies...have identified information technology as the foundation of modern warfighting."

So long as the U.S. government continues to spend substantially in the area of semiconductor R&D, it seems only logical that industry and government should maintain a forum for open communication and programmatic collaboration. Preserving the cooperative construct that has been demonstrated in SEMATECH will go a long way toward ensuring that the critical technology needs

identified on the road maps of industry and DoD will be addressed. Furthermore, maintaining a formal mechanism for information sharing should minimize unnecessary duplication of research efforts and allow each party to more prudently manage limited R&D dollars.

The inherent alignment between the needs of the U.S. industry and DoD will not diminish simply because SEMATECH's reliance on direct federal funding has come to an end. It is important that the operational model for cooperative R&D which is manifest in SEMATECH not be abandoned simply because the funding model of the enterprise is evolving.

That SEMATECH and DoD should continue cooperation beyond 1997 is clear. There is no requirement that the existing cooperative framework, e.g., the grant agreement, memorandum of understanding and enabling legislation be terminated. Elements of the framework for continued cooperation include, but are not limited to, the following:

- DARPA should continue its participation as a non-voting observer on the SEMATECH Board of Directors and the Executive Technical Advisory Board.
- DARPA (or a DoD designee of their choice) is encouraged to attend meetings of the Focus Technical Advisory Boards and Project Technical Advisory Boards.
- DARPA and SEMATECH should conduct a joint, annual review during which the annual operating and long range strategic plans of each organization will be shared. (DARPA should share no government classified information with SEMATECH during the course of such reviews.)
- SEMATECH should continue to be an invited participant in meetings of the Semiconductor Technology Council. Because SEMATECH has ceased to seek federal funds, the possibility of formal SEMATECH representation on the STC should be considered.
- Pursuant to P.L. 100-180, SEMATECH will continue the use of all assets purchased with regular (commingled) operating funds, unless and until dissolution of the corporation.
- Pursuant to its status as a wholly private, nonprofit corporation and consistent with P.L. 104-66, SEMATECH will no longer be subject to audits by the GAO or other federal audit or oversight agencies.

- Pursuant to its status as a wholly private, nonprofit corporation, SEMATECH will no longer be subject to the regulations and requirements set forth in OMB circulars A-110, A-122 and A-133.

## **Summary**

The bold experiment in industry-government cooperation known as SEMATECH has been a remarkable success. The U.S. has regained a position of preeminence in the global semiconductor industry and a rigorous model for cooperative research and development has been demonstrated. The success realized by the participants would never have been possible without the vision and commitment of countless supporters in the Congress and several Administrations. Their willingness to forego traditional regulatory burdens and break new ground in collaborative research should be commended. SEMATECH and DoD should not stop short, but should build on their success and develop a framework for continued cooperation in 1998 and beyond.